MEMORANDUM

TO:	Sheila Abraham Ohio EPA	July 21, 2005 Project No.: 933-6154
cc:	Mary Logan, USEPA Rainer Domalski, ROC	
FR:	Steve Finn/Andrew Joslyn	
RE:	**MIDDLE FORK LITTLE BEAVER CREEK, OHIO REVIEW OF DIRECT CONTACT ADVISORY**	

As requested by the Ohio Environmental Protection Agency (Ohio EPA) and the U.S. Environmental Protection Agency (USEPA) and on behalf of RÜTGERS Organics Corporation (ROC), Golder Associates has reviewed currently available data for the Middle Fork Little Beaver Creek (MFLBC) and associated direct contact risks in relation to the present wading and swimming advisory. The following sections of this memorandum present background information, available data, and direct contact risk calculations. The conclusions of this review support lifting of the direct contact advisory.

Background

The State of Ohio currently recommends that a person not swim or wade in the Middle Fork Little Beaver Creek from State Route alt 14 at Allen Road to State Route 11, south of Lisbon (see Figure 1). This direct contact advisory was placed on the MFLBC in March 1988 by the Ohio Department of Health due to concerns associated with mirex contamination. Mirex in the MFLBC is believed to originate from the former Nease Chemical manufacturing site[1] in Salem, which was located at the upstream extent of the advisory zone. Extensive and continuing investigations of the extent of mirex in the MFLBC and surrounding areas have been undertaken under the direction of USEPA and Ohio EPA over the past 15 years. These investigations have shown that mirex can be transported in the environment with fine grained sediment material, but, consistent with its lack of solubility, mirex has not been detected in surface water in MFLBC. The investigation fieldwork included sediment, floodplain soil, surface water, and fish sampling events in 1982, 1983, 1985, 1987, 1990, 1997, 1999, and 2001. Available data for sediment and surface water from these investigations are included as Tables 1 and 2 respectively. One hundred fifteen (115) sediment samples have been collected from the MFLBC and tributary streams[2], 70 of which had detections of mirex. The highest detection of mirex in sediment was 2,820 ug/kg at Station 12 near the western crossing of the MFLBC by Middletown Road (see Figure 1). A total of 21 surface water samples have been collected from the MFLBC and tributaries, all of which were non-detect for mirex. The reporting limit for mirex in surface water was 0.0054 ug/L but detections were not identified down to the method detection limit of approximately 0.0027 ug/L.

[1] The former Nease Chemical manufacturing site is a Superfund site consisting of 44 acres along state Route 14, two and a half miles northwest of Salem on the Columbiana-Mahoning county line. Between 1961 and 1973, Nease Chemical produced various household cleaning compounds, fire retardants and pesticides – some of which included mirex. The company used ponds to treat waste water from the manufacturing process. Runoff from the plant facility previously flowed into Feeder Creek, which is a tributary of the MFLBC. The ponds were decommissioned by placement of backfill in the 1970s.

[2] One tributary (Feeder Creek) conveys runoff from the Nease site area to MFLBC, and is being addressed as part of the Operable Unit 3 CERCLA remediation project such that it will not re-contaminate MFLBC in the future. The tributary data presented herein therefore does not include Feeder Creek.

Since the direct contact advisory was issued in 1988, various measures have been taken at the Site, under the direction of USEPA and Ohio EPA, to mitigate potential releases of contaminants to the MFLBC. Structures installed on-Site provide for surface water detention with sediment control outlet structures (including berms, aggregate and fabric filters, and elevated outlet control pipes) and surface water diversions to route run-on around the Site so that run-off does not become contaminated. Multiple fabric barriers were also placed in Feeder Creek so that any sediment escaping the on-Site outlet control structures is captured by this secondary mechanism (RNC, 1996). These structures have been maintained and enhanced since 1990, including periodic inspections and sediment cleanout with appropriate off-Site disposal.

Risk Evaluation

The potential risk to human health associated with mirex in the MFLBC was assessed via a formal Endangerment Assessment (EA) that was extensively reviewed and approved by USEPA and Ohio EPA in August 2004. The EA used appropriately conservative (health-protective) assumptions in assessing potential risks associated with exposure to the MFLBC. Considering the full length of the MFLBC within the advisory area and beyond, the risks associated with "reasonable maximum exposures" were assessed using USEPA methodologies. This assessment concluded that possible risks from direct contact exposure to mirex in MFLBC were acceptable, for both adults and children[3]. Portions of the EA relevant to the direct contact advisory are summarized below.

The EA included assessment of risks to both residents and recreational visitors who may contact the creek assuming that an advisory was not in place. Direct contact exposure routes that were evaluated included:

- Ingestion of surface water;
- Dermal contact with surface water;
- Ingestion of sediment; and,
- Dermal contact with sediment.

Tables 3 and 4 present the risk calculations, for ingestion and dermal contact respectively, based upon USEPA toxicity data, and a reasonable maximum exposure concentration of 519 ug/kg of mirex in sediment. Combining the risks from the dermal and ingestion pathways, a non-cancer hazard quotient of 0.00354 and a cancer risk of 5.33×10^{-8} were calculated for mirex exposure. USEPA identifies hazard quotients less than or equal to 1.0 and cancer risks not exceeding a range of 1×10^{-4} to 1×10^{-6} as acceptable.

Since risk is directly proportional to concentration, a mirex threshold concentration corresponding to the lower limit of USEPA's acceptable risk range may be deduced from the calculations presented in Tables 3 and 4. As shown in Appendix A, the most conservative (lowest) mirex threshold concentration is 9,737 ug/kg based on a cancer risk of 1×10^{-6}. As noted in Table 1, the absolute maximum mirex concentration measured in the MFLBC was 2,820 ug/kg, indicating that an advisory is not required for sediment exposure at any of the sampled locations, which provide extensive coverage throughout the current advisory area.

[3] The calculated risks are based on children where they would be higher than for adults. For example, non-cancer risks due to ingestion are based on children alone, while cancer risks due to ingestion are based on combined lifetime exposures of children and adults.

Although mirex was not detected in surface water, an assessment of acceptable mirex levels in surface water has been made based on the calculation methodology presented in the approved EA. Table 5 presents calculations of the maximum allowable concentration[4] of mirex in surface water of the MFLBC that would be protective for direct contact exposures, including both dermal and ingestion pathways. The most stringent maximum allowable mirex concentration in surface water is calculated to be 0.293 ug/l based on potential cancer risk. As noted above, mirex was not detected anywhere in MFLBC surface water with detection limits that were two orders of magnitude below this most stringent direct contact risk-based criterion.

While the MFLBC direct contact advisory is based upon mirex concerns, the Remedial Investigation and the EA also included consideration of the related organochlorine compounds, photomirex and kepone. Kepone was not detected in MFLBC sediment or surface water, photomirex was not detected in surface water, and the reasonable maximum exposure concentration of photomirex in sediment was 17 ug/kg (compared to 519 ug/kg for mirex). As a result, the risks associated with these chemicals are much lower than for mirex and do not exceed USEPA acceptable threshold levels.

Conclusion

Extensive sampling of the sediment and surface water of the MFLBC has been undertaken since the current direct contact advisory for mirex was first issued in 1988. Controls have also been put in place at the Nease site to mitigate further releases to the MFLBC. These activities, together with a formal Endangerment Assessment, have been undertaken under the direction of USEPA and Ohio EPA. Using the risk assessment methodologies contained in the Agency-approved EA, which assume that an advisory is *not* in place, direct contact risks within the advisory area have been shown to be acceptable and well below USEPA threshold criteria. As a result, it is considered that a direct contact advisory is no longer necessary for the MFLBC. Additional response actions, if any are needed, will be conducted with USEPA and Ohio EPA oversight through the CERCLA remediation process. The final CERCLA remedy will ensure that MFLBC will not become re-contaminated.

References

Environ, 2004. Endangerment Assessment for the Nease Chemical Company Salem, Ohio Site. April 2004.

Ohio EPA Website - information on the direct contact advisory.
http://www.epa.state.oh.us/dsw/fishadvisory/donotwade.html Accessed 04/18/2005

RNC, 1996. Remedial Investigation Report, Nease Site, Salem, Ohio. Compiled by Golder Associates Inc., Mt. Laurel, NJ. May 1996.

[4] The "maximum allowable concentration" discussed in this memorandum is not a regulatory criterion or cleanup level, but rather a risk-based value calculated for a specific receptor population based on single-chemical and single-media considerations. This value may or may not be appropriate for other receptor populations with different levels of exposure or with exposure to media other than surface water and sediment.

Table 1
Mirex in Sediment Results 1985-1999
Middle Fork Little Beaver Creek, Ohio

Year	River mile	Mirex Concentration	Reporting Limit	Qualifier	Units	River	Sampling Organization
1985	27.8	ND	1	U	ug/kg	MFLBC	Ohio EPA
1985	36.7	ND	8.7	U	ug/kg	MFLBC	Ohio EPA
1987	4.5	ND	60	U	ug/kg	Little Beaver Creek	USEPA
1987	11.0	ND	60	U	ug/kg	Little Beaver Creek	USEPA
1987	14.4	ND	60	U	ug/kg	Little Beaver Creek	USEPA
1987	4.6	ND	60	U	ug/kg	MFLBC	USEPA
1987	9.0	ND	60	U	ug/kg	MFLBC	USEPA
1987	15.1	ND	60	U	ug/kg	MFLBC	USEPA
1987	17.5	ND	60	U	ug/kg	MFLBC	USEPA
1987	23.5	ND	60	U	ug/kg	MFLBC	USEPA
1987	24.5	230			ug/kg	MFLBC	USEPA
1987	25.1	38			ug/kg	MFLBC	USEPA
1987	26.4	90			ug/kg	MFLBC	USEPA
1987	27.1	150			ug/kg	MFLBC	USEPA
1987	28.8	ND	60	U	ug/kg	MFLBC	USEPA
1987	30.1	1500			ug/kg	MFLBC	USEPA
1987	31.0	220			ug/kg	MFLBC	USEPA
1987	32.0	ND	60	U	ug/kg	MFLBC	USEPA
1987	33.3	1400			ug/kg	MFLBC	USEPA
1987	34.2	510			ug/kg	MFLBC	USEPA
1987	35.4	340			ug/kg	MFLBC	USEPA
1987	36.7	640			ug/kg	MFLBC	USEPA
1987	37.5	1500			ug/kg	MFLBC	USEPA
1987	37.6	ND	60	U	ug/kg	MFLBC	USEPA
1987	38.6	ND	60	U	ug/kg	MFLBC	USEPA
1987	0.2	ND	60	U	ug/kg	North Fork Little Beaver Creek	USEPA
1987	4.1	ND	60	U	ug/kg	West Fork Little Beaver Creek	USEPA
1990	1.5	102			ug/kg	Cherry Valley Run	Nease
1990	4.5	ND	18.5	U	ug/kg	Little Beaver Creek	Nease
1990	6.9	ND	18.5	U	ug/kg	Little Beaver Creek	Nease
1990	11.0	ND	18.5	U	ug/kg	Little Beaver Creek	Nease
1990	14.4	ND	18.5	U	ug/kg	Little Beaver Creek	Nease
1990	1.3	ND	18.5	U	ug/kg	MFLBC	Nease
1990	1.9	10.9		J	ug/kg	MFLBC	Nease
1990	4.7	6.3		J	ug/kg	MFLBC	Nease
1990	7.0	ND	18.5	U	ug/kg	MFLBC	Nease
1990	7.2	10.5		J	ug/kg	MFLBC	Nease
1990	7.6	ND	18.5	U	ug/kg	MFLBC	Nease
1990	12.4	ND	18.5	U	ug/kg	MFLBC	Nease
1990	12.4	ND	18.5	U	ug/kg	MFLBC	Nease
1990	13.1	58.8			ug/kg	MFLBC	Nease
1990	15.1	24.1		J	ug/kg	MFLBC	Nease
1990	17.5	ND	18.5	U	ug/kg	MFLBC	Nease
1990	19.3	18.5		J	ug/kg	MFLBC	Nease
1990	19.5	78.5			ug/kg	MFLBC	Nease
1990	19.6	33.7			ug/kg	MFLBC	Nease
1990	21.5	41.5			ug/kg	MFLBC	Nease
1990	21.7	100		J	ug/kg	MFLBC	Nease
1990	22.5	158			ug/kg	MFLBC	Nease
1990	23.9	181			ug/kg	MFLBC	Nease
1990	24.5	127			ug/kg	MFLBC	Nease
1990	25.3	107			ug/kg	MFLBC	Nease
1990	26.3	175		J	ug/kg	MFLBC	Nease
1990	27.1	45.5			ug/kg	MFLBC	Nease
1990	27.8	403		J	ug/kg	MFLBC	Nease
1990	28.5	125			ug/kg	MFLBC	Nease
1990	28.5	93.7		J	ug/kg	MFLBC	Nease

Table 1
Mirex in Sediment Results 1985-1999
Middle Fork Little Beaver Creek, Ohio

Year	River mile	Mirex Concentration	Reporting Limit	Qualifier	Units	River	Sampling Organization
1990	28.5	ND	18.5	U	ug/kg	MFLBC	Nease
1990	28.8	57.5			ug/kg	MFLBC	Nease
1990	29.1	76.7		J	ug/kg	MFLBC	Nease
1990	29.7	34.6			ug/kg	MFLBC	Nease
1990	30.1	150		J	ug/kg	MFLBC	Nease
1990	31.4	1200		J	ug/kg	MFLBC	Nease
1990	32.0	555			ug/kg	MFLBC	Nease
1990	33.2	2820		J	ug/kg	MFLBC	Nease
1990	33.8	527			ug/kg	MFLBC	Nease
1990	35.0	1680			ug/kg	MFLBC	Nease
1990	37.5	251			ug/kg	MFLBC	Nease
1990	37.7	150			ug/kg	MFLBC	Nease
1990	37.8	ND	18.5	U	ug/kg	MFLBC	Nease
1990	37.9	ND	18.5	U	ug/kg	MFLBC	Nease
1990	37.9	4.26		J	ug/kg	MFLBC	Nease
1990	38.5	7.84		J	ug/kg	MFLBC	Nease
1990	38.5	ND	18.5	U	ug/kg	MFLBC	Nease
1990	0.1	ND	18.5	U	ug/kg	North Fork Little Beaver Creek	Nease
1990	2.0	ND	18.5	U	ug/kg	Stone Mill Run	Nease
1990	4.1	ND	18.5	U	ug/kg	West Fork Little Beaver Creek	Nease
1993	21.7	32.2			ug/kg	MFLBC	Nease
1993	21.7	223			ug/kg	MFLBC	Nease
1993	22.0	138.5			ug/kg	MFLBC	Nease
1993	30.1	24			ug/kg	MFLBC	Nease
1993	30.2	29.2			ug/kg	MFLBC	Nease
1993	30.3	20.5			ug/kg	MFLBC	Nease
1993	30.6	37.9			ug/kg	MFLBC	Nease
1993	30.7	11.9			ug/kg	MFLBC	Nease
1993	35.1	179			ug/kg	MFLBC	Nease
1993	35.3	1190			ug/kg	MFLBC	Nease
1993	35.3	191			ug/kg	MFLBC	Nease
1995	32.5	277			ug/kg	MFLBC	Nease
1995	34.3	344			ug/kg	MFLBC	Nease
1995	36.0	ND	0.99	U	ug/kg	MFLBC	Nease
1995	36.9	ND	1.1	U	ug/kg	MFLBC	Nease
1999	4.5	ND	6.98	U	ug/kg	Little Beaver Creek	Ohio EPA
1999	8.0	ND	5.17	U	ug/kg	Little Beaver Creek	Ohio EPA
1999	15.0	13.3			ug/kg	Little Beaver Creek	Ohio EPA
1999	1.9	ND	5.22	U	ug/kg	MFLBC	Ohio EPA
1999	1.9	ND	16.7	U	ug/kg	MFLBC	Nease
1999	4.4	3.3		J	ug/kg	MFLBC	Nease
1999	9.0	13.8			ug/kg	MFLBC	Ohio EPA
1999	15.1	24.8		N	ug/kg	MFLBC	Nease
1999	20.9	29.4		N	ug/kg	MFLBC	Nease
1999	21.8	4.91		J	ug/kg	MFLBC	Nease
1999	23.5	4.9		J	ug/kg	MFLBC	Nease
1999	25.6	187			ug/kg	MFLBC	Nease
1999	28.8	28		N	ug/kg	MFLBC	Nease
1999	32.0	4.19		J	ug/kg	MFLBC	Nease
1999	33.3	361		D	ug/kg	MFLBC	Nease
1999	36.7	504		D	ug/kg	MFLBC	Nease
1999	37.6	21.2		N	ug/kg	MFLBC	Nease
1999	38.3	ND	16.7	U	ug/kg	MFLBC	Nease
1999	40.3	ND	16.7	U	ug/kg	MFLBC	Nease
1999	7.6	ND	5.37	U	ug/kg	North Fork Little Beaver Creek	Ohio EPA
1999	2.0	ND	5.13	U	ug/kg	Stone Mill Run	Ohio EPA

Table 1
Mirex in Sediment Results 1985-1999
Middle Fork Little Beaver Creek, Ohio

Year	River mile	Mirex Concentration	Reporting Limit	Qualifier	Units	River	Sampling Organization
1999	0.8	ND	6.18	U	ug/kg	West Fork Little Beaver Creek	Ohio EPA
1999	12.9	ND	6.49	U	ug/kg	West Fork Little Beaver Creek	Ohio EPA

Notes:
Qualifiers are defined as follows:
- U = *Analyte not detected*
- J = Analyte detected below the sample reporting limit, concentration is estimated.
- D = Compound is present; result reported from a secondary dilution of the sample extract.
- N = Tentatively Identified. Analyte presence strongly indicated but ion abundance ratio criteria are not met. This may be due to sample matrix effects.

Reporting Limits are only listed for non-detect samples
'ND' denotes that mirex was not detected in the given sample.
Stone Mill Run and Cherry Valley Run are tributaries to the MFLBC
Little Beaver Creek is the stream formed when the MFLBC meets the West Fork Little Beaver Creek.
The North Fork Little Beaver Creek is a tributary to Little Beaver Creek.

Table 2
Mirex in Surface Water Results
Middle Fork Little Beaver Creek, Ohio

Sample ID	River Mile	River	Result	Reporting Limit	Units	Qualifier
RNS-SW-30	1.5	Cherry Valley Run	ND	0.0054	µg/l	U
RNS-SW-52	4.5	Little Beaver Creek	ND	0.0054	µg/l	U
RNS-SW-48	14.4	Little Beaver Creek	ND	0.0054	µg/l	U
RNS-SW-42	7.2	Middle Fork Little Beaver Creek	ND	0.0054	µg/l	U
RNS-SW-40	12.4	Middle Fork Little Beaver Creek	ND	0.0054	µg/l	U
RNS-SW-35	17.5	Middle Fork Little Beaver Creek	ND	0.0054	µg/l	U
RNS-SW-28	21.7	Middle Fork Little Beaver Creek	ND	0.0054	µg/l	U
RNS-SW-23	25.3	Middle Fork Little Beaver Creek	ND	0.0054	µg/l	U
RNS-SW-20	27.8	Middle Fork Little Beaver Creek	ND	0.0054	µg/l	U
RNS-SW-18	28.8	Middle Fork Little Beaver Creek	ND	0.0054	µg/l	U
RNS-SW-13	32.0	Middle Fork Little Beaver Creek	ND	0.0054	µg/l	U
RNS-SW-08	36.0	Middle Fork Little Beaver Creek	ND	0.0054	µg/l	U
RNS-SW-07	37.5	Middle Fork Little Beaver Creek	ND	0.0054	µg/l	U
RNS-SW-05	37.7	Middle Fork Little Beaver Creek	ND	0.0054	µg/l	U
RNS-SW-04	37.8	Middle Fork Little Beaver Creek	ND	0.0054	µg/l	U
RNS-SW-03	37.9	Middle Fork Little Beaver Creek	ND	0.0054	µg/l	U
RNS-SW-02	37.9	Middle Fork Little Beaver Creek	ND	0.0054	µg/l	U
RNS-SW-01	38.5	Middle Fork Little Beaver Creek	ND	0.0054	µg/l	U
RNS-SW-50	0.1	North Fork Little Beaver Creek	ND	0.0054	µg/l	U
RNS-SW-29	2.0	Stone Mill Run	ND	0.0054	µg/l	U
RNS-SW-47	4.1	West Fork Little Beaver Creek	ND	0.0054	µg/l	U

Notes:
Qualifiers are defined as follows:
U = Analyte not detected

'ND' denotes that mirex was not detected in the given sample.
Stone Mill Run and Cherry Valley Run are tributaries to the MFLBC
Little Beaver Creek is the stream formed when the MFLBC meets the West Fork Little Beaver Creek.
The North Fork Little Beaver Creek is a tributary to Little Beaver Creek.
All samples collected by Nease, April 1990.

Table 3

Estimation of Potential Mirex Risks Associated with Ingestion of Sediment
Middle Fork Little Beaver Creek, Ohio

$$CDI_{carc} = \frac{CS\ x \left(\frac{10^{-6}kg}{mg}\right) xET\ x\ EF}{AT} x \left(\frac{IR_{adult}\ x\ ED_{adult}}{BW_{adult}} + \frac{IR_{child}\ x\ ED_{child}}{BW_{child}}\right)$$

$$CDI_{nonc} = \frac{CS\ x \left(\frac{10^{-6}kg}{mg}\right) x\ IR_{child}\ x\ ET\ x\ EF\ x\ ED_{child}}{BW_{child}\ x\ AT}$$

$$CancerRisk = CDI\ xCSF \qquad NonCancerHQ = \frac{CDI}{RfD}$$

Parameter	Definition	Reasonable Maximum Exposure Value	
		Cancer Effects	Non-Cancer Effects
CS	Mirex concentration in sediment, mg/kg	5.19 E-01	5.19 E-01
ET	Fraction of time exposed to contam. source, unitless	1.0	1.0
EF	Exposure frequency, days/yr	70	70
AT	Averaging time, days	25,550	2,190
IR_{adult}	Adult ingestion rate, mg/day	50	---
ED_{adult}	Adult exposure duration, yrs	24	---
BW_{adult}	Adult body weight, kg	70	---
IR_{child}	Child ingestion rate, mg/day	100	100
ED_{child}	Child exposure duration, yrs	6	6
BW_{child}	Child body weight, kg	15	15
CDI	Chronic daily intake, mg/kg-day	8.13 E-08	6.64 E-07
CSF	Cancer slope factor $(mg/kg/day)^{-1}$	5.30 E-01	---
CancerRisk	Excess lifetime cancer risk, unitless	4.31 E-08	---
RfD	Reference dose (mg/kg/day)	---	2.00 E-04
NonCancerHQ	Hazard quotient, unitless	---	3.32 E-03

Note:
Methodology and all exposure values taken from the approved EA.

Table 4

Estimation of Potential Mirex Risk Associated with Dermal Contact with Sediment
Middle Fork Little Beaver Creek, Ohio

$$CDI = \frac{CS\ x \left(\frac{10^{-6}\,kg}{mg}\right) x\ SA\ x\ ABS\ x\ AF\ x\ ET\ x\ EF\ x\ ED}{BW\ x\ AT}$$

$$CancerRisk = CDI\ x\ CSF \qquad NonCancerHQ = \frac{CDI}{RfD}$$

Parameter	Definition	Reasonable Maximum Exposure Value	
		Cancer Effects	**Non-Cancer Effects**
CS	Mirex concentration in sediment, mg/kg	5.19 E-01	5.19 E-01
SA	Skin surface area available for contact, cm^2	4,500	4,500
ABS	Absorption factor	0.1	0.1
AF	Adherence factor of soil to skin, mg/cm^2	0.07	0.07
ET	Fraction of time exposed to contam. source, unitless	1.0	1.0
EF	Exposure frequency, days/yr	70	70
ED	Exposure duration, yrs	30	30
BW	Body weight, kg	70	70
AT	Averaging time, days	25,550	10,950
CDI	Chronic daily intake, mg/kg-day	1.92 E-08	4.48 E-08
CSF	Cancer slope factor $(mg/kg/day)^{-1}$	5.30 E-01	---
CancerRisk	Excess lifetime cancer risk, unitless	1.02 E-08	---
RfD	Reference dose (mg/kg/day)	---	2.00 E-04
NonCancerHQ	Hazard quotient, unitless	---	2.24 E-04

Note:
Methodology and all exposure values taken from the approved EA.

Table 5

Estimation of Risk-Based Maximum Allowable Mirex Concentration in Surface Water
Middle Fork Little Beaver Creek, Ohio

$$CancerRisk = CSF \times (CDI_{ing} + CDI_{derm}) \qquad NonCancerHQ = \frac{(CDI_{ing} + CDI_{derm})}{RfD}$$

Chronic Daily Intake from Ingestion of Surface Water

$$CDI_{ing} = \frac{CW \times \left(\frac{10^{-3}\,mg}{ug}\right) \times IR \times ET \times EF \times ED}{BW \times AT}$$

Parameter	Definition	Reasonable Maximum Exposure Value	
		Cancer Effects	**Non-Cancer Effects**
CW	Risk-based max. allowable mirex in water, ug/L	Calculated Value	Calculated Value
ET	Fraction of time exposed to contam. source, unitless	1.0	1.0
EF	Exposure frequency, days/yr	70	70
AT	Averaging time, days	25,550	10,950
IR	Adult ingestion rate, L/day	0.05	0.05
ED	Exposure duration, yrs	30	30
BW	Body weight, kg	70	70
CDI_{ing}	Chronic daily intake from ingestion, mg/kg-day	Calculated Value	Calculated Value
CDI_{derm}	Chronic daily intake from dermal contact, mg/kg-day	Calculated Value	Calculated Value
CSF	Cancer slope factor $(mg/kg/day)^{-1}$	5.30 E-01	Not Applicable
CancerRisk	Threshold allowable excess lifetime cancer risk, unitless	1×10^{-6}	Not Applicable
RfD	Reference dose (mg/kg/day)	Not Applicable	2.00 E-04
NonCancerHQ	Threshold allowable Hazard quotient, unitless	Not Applicable	1.0

Note:
Methodology and all exposure values taken from the approved EA.

Table 5

**Estimation of Risk-Based Maximum Allowable Mirex Concentration in Surface Water
Middle Fork Little Beaver Creek, Ohio**

Chronic Daily Intake from Dermal Contact with Surface Water

$$CDI_{derm} = \frac{DA_{event} \times SA \times EF \times ED}{BW \times AT}$$

$$DA_{event} = 2 \times FA \times K_P \times CW \times \left[\frac{6 \times \tau \times t_{event}}{\pi}\right]^{1/2} \times \left(10^{-3}\frac{mg}{ug}\right) \times \left(10^{-3}\frac{L}{cm^3}\right)$$

$$K_P = 10^{-2.8+0.67 \times \log K_{OW} - 0.0056 \times MW}$$

Parameter	**Definition**	**Reasonable Maximum Exposure Value**	
		Cancer Effects	**Non-Cancer Effects**
DA_{event}	Mirex dose absorbed per event, mg/cm^2/event	Calculated Value	Calculated Value
SA	Skin surface area available for contact, cm^2	4,500	4,500
EF	Exposure frequency, events/yr	70	70
ED	Exposure duration, yrs	30	30
BW	Body weight, kg	70	70
AT	Averaging time, days	25,550	10,950
CDI_{derm}	Chronic daily intake from dermal contact, mg/kg-day	Calculated Value	Calculated Value
FA	Fraction absorbed, unitless	0.4	0.4
K_p	Permeability coefficient, cm/hr	0.0577	0.0577
CW	Risk-based max. allowable mirex in water, ug/L	Calculated Value	Calculated Value
τ	Lag time, hrs	119.3	119.3
t_{event}	Duration of event, hr/event	3	3
log K_{ow}	Log of Octanol-Water Partition Coefficient, unitless	6.89	6.89
MW	Molecular weight, g/mol	545.5	545.5

Note:
Methodology and all exposure values taken from the approved EA.

Table 5

Estimation of Risk-Based Maximum Allowable Mirex Concentration in Surface Water
Middle Fork Little Beaver Creek, Ohio

Maximum Allowable Mirex Concentration in Surface Water

Cancer Risk-Based:

$$CancerRisk = CSF \times (CDI_{ing} + CDI_{derm})$$

$$CancerRisk = CSF \times \frac{EF \times ED}{BW \times AT} \times CW \times \left(\frac{10^{-3}\,mg}{ug}\right) \times \left[IR \times ET + 2 \times SA \times FA \times K_p \times \left(\frac{6 \times \tau \times t_{event}}{\pi}\right)^{1/2} \times \left(10^{-3}\frac{L}{cm^3}\right)\right]$$

$$CW = \frac{CancerRisk}{CSF \times \frac{EF \times ED}{BW \times AT} \times \left(\frac{10^{-3}\,mg}{ug}\right) \times \left[IR \times ET + 2 \times SA \times FA \times K_p \times \left(\frac{6 \times \tau \times t_{event}}{\pi}\right)^{1/2} \times \left(10^{-3}\frac{L}{cm^3}\right)\right]}$$

$$CW = 0.293\,ug/L$$

Non-Cancer Risk-Based:

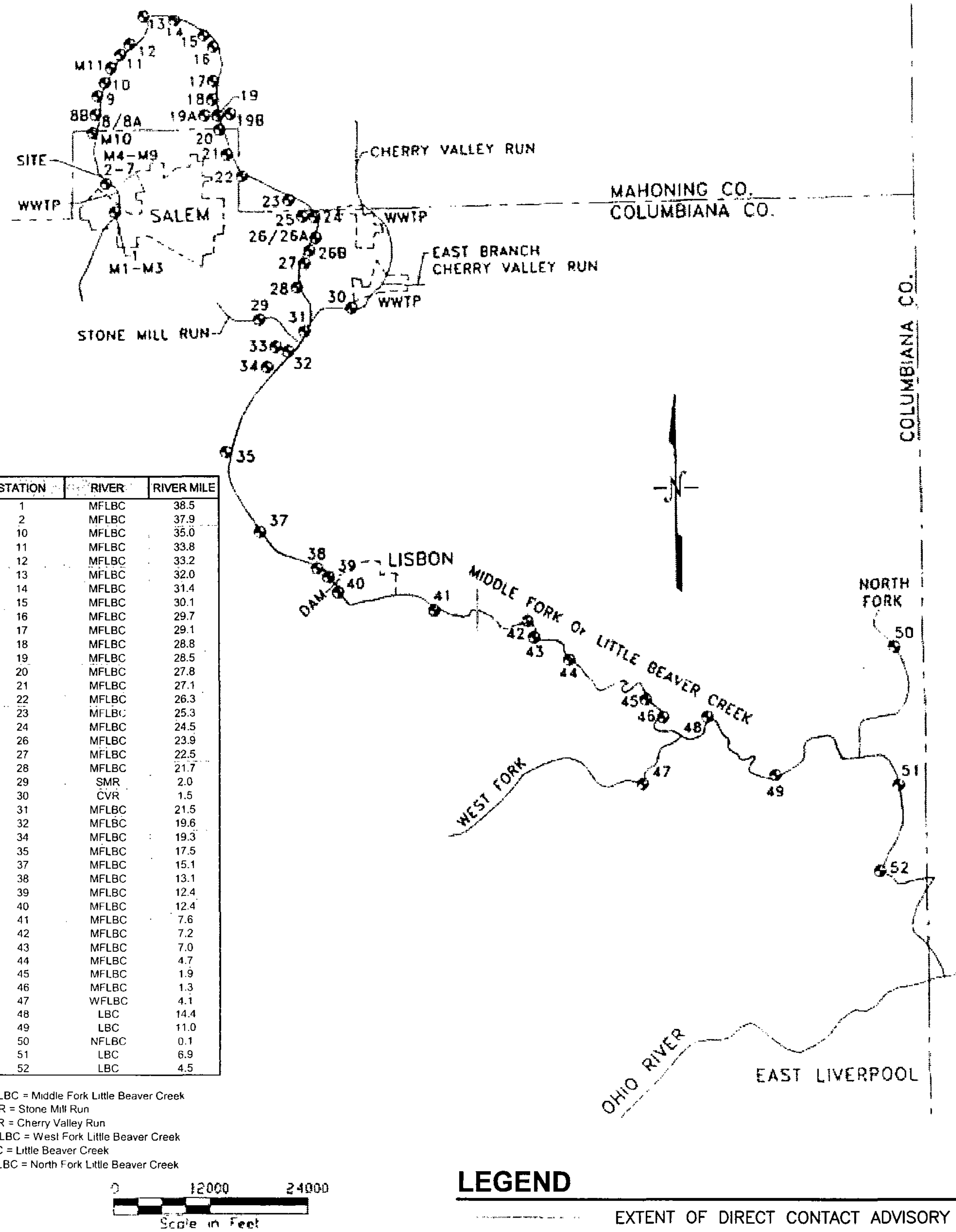
$$NonCancerHQ = \frac{(CDI_{ing} + CDI_{derm})}{RfD}$$

$$NonCancerHQ = \frac{1}{RfD} \times \frac{EF \times ED}{BW \times AT} \times CW \times \left(\frac{10^{-3}\,mg}{ug}\right) \times \left[IR \times ET + 2 \times SA \times FA \times K_p \times \left(\frac{6 \times \tau \times t_{event}}{\pi}\right)^{1/2} \times \left(10^{-3}\frac{L}{cm^3}\right)\right]$$

$$CW = \frac{NonCancerHQ \times RfD}{\frac{EF \times ED}{BW \times AT} \times \left(\frac{10^{-3}\,mg}{ug}\right) \times \left[IR \times ET + 2 \times SA \times FA \times K_p \times \left(\frac{6 \times \tau \times t_{event}}{\pi}\right)^{1/2} \times \left(10^{-3}\frac{L}{cm^3}\right)\right]}$$

$$CW = 13.3\,ug/L$$

Notes:
1. Methodology and all exposure values taken from the approved EA.
2. The "maximum allowable concentrations" calculated herein are not regulatory criteria or cleanup levels, but rather risk-based values calculated for a specific receptor population based on single-chemical and single-media considerations. These values may not be appropriate for other receptor populations with different levels of exposure or with exposure to media other than surface water.



STATION	RIVER	RIVER MILE
1	MFLBC	38.5
2	MFLBC	37.9
10	MFLBC	35.0
11	MFLBC	33.8
12	MFLBC	33.2
13	MFLBC	32.0
14	MFLBC	31.4
15	MFLBC	30.1
16	MFLBC	29.7
17	MFLBC	29.1
18	MFLBC	28.8
19	MFLBC	28.5
20	MFLBC	27.8
21	MFLBC	27.1
22	MFLBC	26.3
23	MFLBC	25.3
24	MFLBC	24.5
26	MFLBC	23.9
27	MFLBC	22.5
28	MFLBC	21.7
29	SMR	2.0
30	CVR	1.5
31	MFLBC	21.5
32	MFLBC	19.6
34	MFLBC	19.3
35	MFLBC	17.5
37	MFLBC	15.1
38	MFLBC	13.1
39	MFLBC	12.4
40	MFLBC	12.4
41	MFLBC	7.6
42	MFLBC	7.2
43	MFLBC	7.0
44	MFLBC	4.7
45	MFLBC	1.9
46	MFLBC	1.3
47	WFLBC	4.1
48	LBC	14.4
49	LBC	11.0
50	NFLBC	0.1
51	LBC	6.9
52	LBC	4.5

MFLBC = Middle Fork Little Beaver Creek
SMR = Stone Mill Run
CVR = Cherry Valley Run
WFLBC = West Fork Little Beaver Creek
LBC = Little Beaver Creek
NFLBC = North Fork Little Beaver Creek

LEGEND

EXTENT OF DIRECT CONTACT ADVISORY

Golder Associates
Philadelphia USA

SCALE	AS SHOWN	TITLE	LOCATION OF SAMPLING STATIONS
DATE	04/28/05		
DESIGN	APJ		
CADD	AM		
FILE No. 9336154F002	CHECK		
PROJECT No. 933-6154 REV. 0	REVIEW	RÜTGERS ORGANICS CORPORATION	FIGURE 1

Drawing file: 9336154F002.dwg Apr 28, 2005 - 4:43pm

Appendix A

Mirex Sediment Threshold Calculation Worksheets

GOLDER ASSOCIATES	Subject: MIREX THRESHOLD CALCULATION – SEDIMENT		
	Job No: 933-6154	Made by: APJ	Date: 7/62005
	Ref: 933-6154	Checked by: RAL	
	MFLBC	Reviewed by: PSF	Sheet: 1 of 2

OBJECTIVE: To determine the maximum allowable concentration of mirex in sediment in the MFLBC.

REFERENCES:

1) ENVIRON 2004, *Endangerment Assessment for the Nease Chemical Company, Salem Ohio Site* (EA) dated 2004

METHOD & CALCULATIONS:

1) Based on the EA, the calculated mirex risks under the Reasonable Maximum Exposure (RME) scenario are as follows (see Table 3 and 4):

Dermal Contact with Sediment	1.02×10^{-8} (cancer risk) 2.24×10^{-4} (non-cancer hazard quotient)
Incidental Ingestion of Sediment	4.31×10^{-8} (cancer risk) 3.32×10^{-3} (non-cancer hazard quotient)
Combined Sediment Risks	5.33×10^{-8} (cancer risk) 3.54×10^{-3} (non-cancer hazard quotient)

2) Based on the risks summarized in step 1 and the mirex RME concentration for sediment of 519 ug/kg, the maximum allowable mirex concentration in sediment corresponding to a threshold cancer risk of 1×10^{-6} and a non-cancer risk of 1.0 was determined as follows:

A. Cancer Risk

$$Maximum\ Allowable\ Concentration = \frac{Allowable\ Cancer\ Risk}{Calculated\ Cancer\ Risk} \times RME$$

$$Maximum\ Allowable\ Concentration = \frac{1 \times 10^{-6}}{5.33 \times 10^{-8}} \times 519\ ug/kg$$

$$Maximum\ Allowable\ Concentration = 9{,}737\ ug/kg$$

B. Non-cancer Risk

$$Maximum\ Allowable\ Concentration = \frac{Allowable\ Noncancer\ HQ}{Calculated\ Noncancer\ HQ} \times RME$$

$$Maximum\ Allowable\ Concentration = \frac{1.0}{3.54 \times 10^{-3}} \times 519\ ug/kg$$

$$Maximum\ Allowable\ Concentration = 146{,}610\ ug/kg$$

CONCLUSION:

The mirex concentration in sediment that results in the maximum acceptable risk is equal to 9,737 ug/kg (the lower of cancer and non-cancer results). This concentration is not a regulatory criterion or cleanup level, but rather a risk-based value calculated for a specific receptor population based on single-chemical and singe-media concentrations. This value may not be appropriate for other receptor populations with different levels of exposure or with exposure to media other than sediment.